Science Data Validation Plan

MODIS Oceans Group

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1.0 Introduction

MODIS will measure radiance in visible, near-IR, and thermal IR bands that will be used to derive ocean bio-optical and thermal properties. This derivation is subject to uncertainties resulting from the instrument, the atmospheric effects of scattering and absorption, and the relations used to estimate ocean properties from ocean reflectance or emittance in the MODIS spectral bands. The influence of these sources of uncertainty is expected to have considerable spatial and temporal variability, and as such, a continuing validation effort throughout the mission lifetime is required. Within the MODIS Oceans Group (MOCEAN) a capability has been developed to perform a core set of validation studies, consisting of modeling efforts, internal consistency checks, collection of a limited set of *in situ* observations from ships, buoys, drifters, and aircraft, and a processing system for timely comparison of these data with MODIS products. However, due to the immensity of the oceans, the scales of variability, and limited resources, the MOCEAN global validation effort must leave many areas, regions and times unsampled. Uncertainties will have to be assigned to a large fraction of the global ocean from the areas where they have been rigorously determined. Fortunately, there are strong at-sea activities by a number of other NASA projects, US agency programs, and international efforts that will also provide observations useful for validation of the products, and will greatly strengthen this effort.

The initial plans for algorithm validation and data product validation were developed at a time when a SeaWiFS launch was expected in 1993. A close coordination of SeaWiFS Project and MOCEAN (especially for the bio-optical products) was developed under the guidance of NASA HQ. Thus, the MODIS activities relied heavily upon the SeaWiFS Calibration-Validation (Cal/Val) effort. Components of the joint SeaWiFS Cal/Val and MODIS validation effort that are especially important are the development of

protocols for making *in situ* measurements (Mueller and Austin 1995) and the instrument calibration round-robin intercomparison effort (Mueller *et al.*, 1996) for those MODIS products sharing a common heritage with SeaWiFS. As the assumptions used are no longer valid, the plans have evolved over time in an attempt to overcome schedule impacts.

The Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) plan (See NASA NRA-96-MTPE-04), although focused on merging ocean color data sets from multiple satellite missions, e.g., SeaWiFS, OCTS, MODIS, POLDER, etc., contains elements to assure continuation of many of the SeaWiFS/MODIS joint activities, as well as addressing product validation. This plan assumes that the basic SIMBIOS activities will proceed as outlined in the NRA. Especially critical to MODIS ocean validation are the combined data base for *in situ* bio-optical measurements from the larger oceanographic research community, the continued international ocean calibration round-robin activities, including development and maintenance of transfer radiometers, and intercomparision workshops, the Atlantic Meridional Transect as a source of large-scale data for validation, and the validation-specific activities to be funded under an NRA.

1.1 Scientific Objectives

The scientific objectives of the validation effort are to provide data necessary for the initialization of some product algorithms, and for an ongoing effort to describe the uncertainty fields of the standard MODIS Level 2 and 3 ocean products throughout the mission life. This information will be used to identify and remove systematic biases in the data products resulting from the instrument, the algorithms, and data production.

The specific products that require validation are:

- Fundamental radiance products (water-leaving radiance in the visible and surface emittance in the thermal infrared).

- Products relating to the physical and bio-optical state of the water (sea-surface temperature, phytoplankton pigment concentration, chlorophyll *a* concentration, phytoplankton fluorescence, photosynthetically active radiation, suspended solids concentration, organic matter concentration, coccolith/calcite concentration, ocean water attenuation coefficient, total absorption coefficient, gelbstoffe absorption coefficient, aerosol optical thickness, and phycoerythrin concentration).

- Higher-level products (ocean primary productivity, chlorophyll fluorescence efficiency).

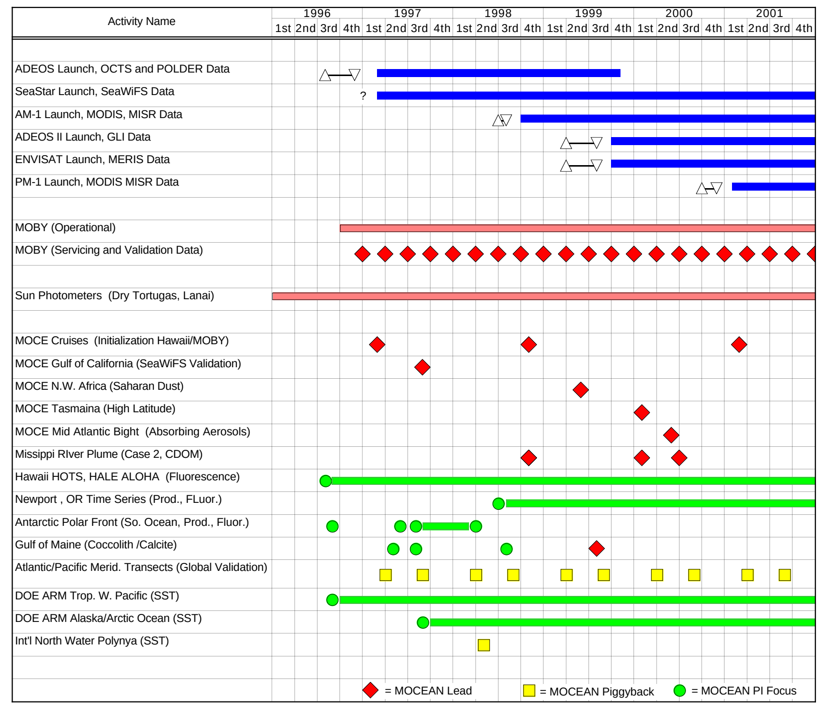
Detailed descriptions of the of the algorithms used to produce these products are provided in the Algorithm Theoretical Basis Documents (ATBD's) available on World Wide Web (http://spso.gsfc.nasa.gov/spso_homepage.html).

1.2 Validation Approach

Several fundamentally different, but complementary, data sets are necessary to provide an adequate sampling of the marine atmospheric conditions, oceanic bio-optical state, and sea-surface temperature (SST), needed to validate the MODIS Ocean Products. Our validation strategy is multi-fold: Highly-focused field expeditions using state-of-the-art calibrated in-water and surface spectral radiometers, supported by extensive instrument suites to determine the state of the atmosphere, are utilized to understand the atmospheric and oceanic processes that limit the accuracy of the derived bio-optical properties and the SST. A permanent buoy-based oceanic optical station is maintained to continuously monitor the performance of the MODIS system (sensor *plus* algorithms). Long-time period, global-scale data sets are obtained to provide a monitoring capability for revealing calibration drift and the consequences of sudden or extreme atmospheric events, such as volcanic eruptions, transoceanic transport of terrestrial aerosols, cold-air outbreaks, etc., on the global products. These data sets will enable MOCEAN to define the uncertainties in products under a variety of conditions as well as providing the information required to fine-tune the algorithms described in the ATBD's.

A schedule of MODIS validation-specific campaigns planned by MOCEAN is provided on the following page.

MOCEAN Validation Activities



1.3 Satellite Missions

The validation activities of the MOCEAN are keyed to the EOS platforms, MODIS AM-1 and MODIS PM-1. The *in situ* observations have been developed with the recognition of their relevance to missions of similar ocean sensors, i.e., SeaWiFS, OCTS, MISR, GLI, MERIS, POLDER, GOES-8, GOES-9, AVHRR, ATSR, and the MOS instruments on PIRODA and IRS.

2.0 Validation Criteria

2.1 Overall Approach

The approach to validation of the MODIS Ocean Products is to compare surface- or *in situ* -measured values with MODIS-retrieved values. The comparisons will be completed for a variety of situations ranging from those for which the performance of the individual algorithm is expected to be excellent to situations for which the performance is expected to be severely degraded.

For the visible products (bio-optical products and water-leaving radiance), the validation begins with initialization of the sensor, i.e., the process of carrying out on-orbit calibration for a newly-launched sensor, prompted by the fact that it is reasonable to expect that the stresses associated with launch may alter radiometric calibration, using a prediction of the radiance expected at the sensor, based on a rigorous set of *in situ* atmospheric measurements and radiative transfer computations. On this basis, the sensor calibration is revised to provide agreement with the predictions.

The validation will be effected using a set of Ocean Test Sites. The role of Ocean Test Sites encompasses the somewhat conflicting needs for intensive validation and initialization data collection, oceanic process studies, time series stations, as well as providing for stratified global observations. Data collected at the time series sites are necessary to validate trends detected in satellite data, and to monitor the response of marine ecosystems and SST to climate change. By including physical and biogeochemical observations, the sites will provide insight on the mechanisms of coupling between biological and physical systems. Data collected at the test sites will be of value to MODIS, MISR, ASTER, and CERES on the EOS AM-1 Platform, as well as other missions (SeaWiFS, ADEOS I, II, TPF, and ENVISAT). The MOCEAN plan maps to the Tier structure proposed by GCOS:

Tier 1: Process studies, initialization cruises, and intensive ocean color and SST validation cruises. Examples of process studies are the JGOFS Arabian Sea Study and JGOFS Southern Ocean Study. Initialization cruises and MODIS Marine Optical Characterization Experiment (MOCE) Cruises will occur annually. Tier 1 efforts are intensive in regions of particular interest for scientific and validation reasons, e.g., a MOCE effort to characterize the

impact of absorbing aerosols on atmospheric correction off NW Africa, and M-AERI deployments to understand relationships between surface brightness temperature and bulk temperature. These studies may include moorings, but for limited duration.

Tier 2: These are high level time-series stations which include measurements of key and ancillary parameters, and possess high accuracy. Examples of these are the MOBY mooring and the JGOFS biogeochemical times series stations at Hawaii (HOT) and Bermuda (BATS). It should be noted that there are presently no coastal sites in the US, although plans are developing. These stations include permanent moorings to provide near continuous, high quality observations directly related to satellite derived data products throughout the 15 year observation period.

Tier 3: The permanent, automated, operational moorings and platforms which usually measure a more limited suite of primarily physical properties. Prime examples of these are the operational weather buoys and tide gauge networks. These sites provide key information for several ocean physical missions such as scatterometry, altimetry, and SST.

Tier 4: This level includes multiple efforts which provide broad global validation data, and includes individual cruise efforts for regional validation as well as expendable optical and SST drifters which report data via satellite links.

Tier 5: Includes combined multi-platform (ship, buoy, aircraft, satellite) multi-year climatologies and model outputs which are used to test consistency of satellite observations.

An initial listing of major Ocean Test Sites, and the degree of commitment to them, is provided in the following table.

MAJOR OCEAN TEST SITES	*LEVEL OF COMMITMENT*
MARINE OPTICAL BUOY (MOBY) - NASA Optics, Bio-Optics	HIGH
HAWAIIAN OCEAN TIME SERIES (HOTS) JGOFS Biogeochemistry & Physics	HIGH
BERMUDA ATLAN. TIME SERIES (BATS) JGOFS Biogeochemistry, Physics & Optics	HIGH
ANTARCTIC LTER Palmer Bio-Optics, Physics	HIGH
MIDDLE ATLANTIC BIGHT (MAB) Repeated Process Studies, Inst. Platforms	UNKNOWN
SOUTHERN CALIFORNIA BIGHT Multi-agency CalCOFI (30 year ship time series)	HIGH
EAST. GULF OF MEXICO NASA, Multi-agency Bio-optics, Case 2, River Plume	HIGH
CHESAPEAKE BAY & PLUME REG. - Multi-agency Case 2 - high variability, low predictability	MIXED
TOGA-TAO Equatorial Pacific & Atlantic, Physics	HIGH
YAMATO BANK OPTICAL MOORING NASDA Optics, Bio-Optics (OCTS Validation)	SIX MONTHS
EUROPEAN SITES, Baltic/North Sea, Eddystone, JRC Sites,	MEDIUM
TASMAN SEA AUSTRALIA Physics, Bio-Optics	HIGH
WOCE LONG LINES & REPEAT SECTIONS WMO Physics	UNKNOWN
ATLANTIC MERIDONAL TRANSITS UK Bio-Optical, Physics	THREE YEARS
HARVEST PLATFORM, TIDE GAUGE NETWORK Sea Level /Altimetry	HIGH
ARM SITES - DOE Radiative Fluxes	HIGH
AERONET - NASA Maritime Aerosol Optics Sites	HIGH

2.2 Sampling requirements and trade-offs

Because of the intense variability in the ocean on mesoscales along with lower frequency processes such as the El Nino/Southern Oscillation (ENSO) events, it is not possible to sample all of the critical conditions and regions adequately. We anticipate non-EOS scientists providing significant quantities of data for comparison with MODIS products, and solicit their help in providing a truly global validation effort. This will be effected in a formal manner through the SIMBIOS program. Also, as part of the methods described in Tier 4 and 5 in Subsection 2.1, sensors will be deployed as either fixed moorings or free-floating drifters in order to characterize temporal and spatial variability. These will help overcome the sampling problems.

2.3 Measures of Success

The simplest measures of success will be the ability of the algorithms to perform within predicted error limits over a broad range of environmental conditions. For example, after the initial validation stage, and the algorithms are fine-tuned based on the results, can they be applied in different ocean regions or different atmospheric conditions and continue to produce data sets within the expected error? The second measure will be an assessment of the stability of the data products over a long time period. For example, are there unexplained biases in the long-term record or unexpected seasonal trends? The third measure is the most stringent and is based on the performance of numerical models that assimilate these data products. In this case, tests will be based on the adequacy of the estimates of error fields as well as an evaluation of model performance. For example, have we sufficiently characterized the temporal and spatial error fields of the data products so that assimilation techniques can be applied? Do numerical models perform better if the data sets are assimilated into the model? The advantage of the data assimilation approach is that a rigorous estimate of the confidence in the model output is produced along with the predicted fields. This last measure of success will be especially useful in the higher level primary productivity data sets.

3.0 Pre-launch Activities

3.1 Algorithm Tests and Development Activities

The pre-launch validation activities of MOCEAN are two-fold. First, instrumentation required to effect the validation, e.g., MOBY and the associated spectroradiometric instrumentation, is being developed or acquired for use in the post-launch era. Second, as the instrumentation becomes available, it is thoroughly tested and then used to acquire data required to develop and validate the algorithms. For example, a micro pulse lidar (MPL) and a M-AERI for at-sea use, to measure the vertical distribution of aerosol concentration and the thermal infrared radiation leaving the sea surface, are being procured in 1996. They will be used during the remainder of the pre-launch phase to measure vertical distributions of absorbing aerosols to guide the creation of model distributions for use in atmospheric correction of MODIS data, and to study the relationship between skin and bulk SST, respectively.

3.2 Surface Networks

There are two surface networks that are highly relevant to validation of MODIS over the ocean: the island AERONET sites and the MOBY site(s). AERONET is a network of CIMEL sun photometers/sky radiometers operated by B. Holben at NASA/GSFC. Island stations of the network yield aerosol properties over the oceans. Data from these sites are being used in support of algorithm development efforts (atmospheric correction). Included are some non-CIMEL stations, such as those operated in Japan. The MOBY site is being used to provide data in support of atmospheric correction and bio-optical algorithm development. Although this is not a network *per se*, MOCEAN has recommended the implementation of MOBY systems at other operational sites.

3.3 Existing Data Sets

The only existing ocean color data set available at this time is the 8-year CZCS record. Most large-scale considerations by MOCEAN are guided by this data set. It is archived at the GSFC DAAC. Additional ocean color data sets expected to be available in the MODIS post-launch era are SeaWiFS, OCTS, POLDER, and MSX. The AVHRR data set is being used to guide the processing of both ocean color and SST data by virtue of the NOAA/NASA Pathfinder effort of R. Evans. ATSR data are also being used in the development of SST algorithms.

3.4 Cruises

A number of cruises have been carried out in support of the algorithm development and validation effort. These include two MOCE cruises (D. Clark) in support of the development of MOBY as well as several cruises dedicated to the deployment and retrieval of MOBY. Numerous cruises were carried out in the Gulf of Mexico (K. Carder) in support of the development of the Chlorophyll *a* algorithm, and in the Gulf of Maine in support of the detached coccolith/calcite algorithm (W. Balch). Two long cruises in the Arabian Sea were carried out by W. Balch as part of a JGOFS effort. These data are being used in support of the development of several bio-optical algorithms. MOCEAN participated in cruises in the Gulf of Mexico and the Tropical Western Pacific (Brown/Minnett) in which the principal SST-validation instrument (M-AERI) was field tested. At-sea participation in the TARFOX experiment was carried out (Gordon/Voss) to provide information for atmospheric correction regarding anthropogenic absorbing aerosols. Twenty-four bio-optical drifters were deployed in the California Current System between 1993 and 1995 and a set of two bio-optical drifters deployed in the Southern Ocean in 1994-1995 (Abbott). These data are being used to develop a set of specific laboratory experiments which were begun in summer 1995 in collaboration with Dr. Paul Falkowski (Brookhaven National Laboratory), which are designed to determine the relationship between sun-stimulated fluorescence and the photosynthetic rate of phytoplankton.

4.0 Post-launch Activities

4.1 Planned Non-EOS Field Activities

In the first three years after the launch of EOS AM-1 we will validate MODIS data by participating in several field campaigns organized by others. These include:

Field Campaign	***Sensors***	***Responsible Team Members***	***Purpose***	***Dates***
Tropical Western Pacific (ARM Site)	M-AERI	Brown & Minnett	SST	Continuing

Field Campaign	*Sensors*	*Responsible Team Members*	*Purpose*	*Dates*
Arctic Ocean (ARM Site)	M-AERI	Brown & Minnett	SST	Continuing
Atlantic Meridonal Transect	M-AERI	Brown, Minnett, MOCEAN	SST, Large-scale Bio-optics	9/98-4/99 9/99-4/00 9/00-4/01
Pacific Meridonal Transect	M-AERI	Brown & Minnett	SST	9/98-4/99 9/99-4/00 9/00-4/01

4.2 New EOS-Targeted Field Campaigns

In the first three years after the launch of EOS AM-1 we will mount field campaigns specifically for the purpose of validation of MODIS data. This data will be compared directly with the associated MODIS data on a pixel-by-pixel basis. These MODIS-specific validation campaigns include:

Location	*Product*	*MODIS Investigator*	*Purpose*	*Date*
Hawaii	Bio-optics, SST, Atmosphere Properties	Clark, MOCEAN	AM-1 Sensor Initialization	10/98
Gulf Mex. Sargasso	Bio-optics	Carder, MOCEAN	Alg. Initial. (Case 1/Case 2)	11/98
TOTO	Bio-optics	Carder, MOCEAN	Near-field scatter	3/99
NW Africa	Bio-optics SST	Clark, MOCEAN	Saharan Dust	6/99
Baffin Bay	SST	Brown, Minnett	Polar Atmosphere	8/99

Location	*Product*	*MODIS Investigator*	*Purpose*	*Date*
MAB	Bio-optics	Carder	Case 1 Case 2 Transition	10/99
Tasmania	Bio-optics	Clark, MOCEAN	High Latitude	2/00
MAB	Bio-optics	Clark, MOCEAN	Urban Aerosols	6/00
GOM Miss.	Bio-optics	Carder	CDOM	6/00
Hawaii	Bio-optics, SST, Atmospheric Properties	Clark, MOCEAN	PM-1 Sensor Initialization	3/01
Gulf of Maine	Bio-optics	Balch	Coccoliths	8/01

The first post-launch EOS-targeted campaign will take place in October 1998 (as soon as possible after MODIS starts producing visible imagery). The purpose is the initialization of the sensor (see Subsection 2.1). This activity will take place at the MOBY site off Hawaii. This site is chosen for logistical reasons, and for the fact that the aerosol concentrations are low. A complete suite of bio-optical measurements (including the water-leaving radiances) will be carried out, along with measurements needed to characterize the columnar properties of the atmosphere, i.e., atmospheric transmission, whole-sky radiance and polarization, solar aureole, and micro pulse lidar. The resulting atmospheric measurements will be used as input to a radiative transfer code to predict the MODIS radiances at the top of the atmosphere (Gordon and Zhang 1996). These will be used to adjust the radiometric calibration of the MODIS ocean bands (8-16).

Following this, two field studies are planned to (1) initialize the Chlorophyll *a* and CDOM algorithms for both Case 1 and Case 2 waters (Gulf of Mexico and Sargasso Sea), and (2) to examine MODIS near-field scatter problem by utilizing imagery from the Tongue of the Ocean (TOTO) in the Bahamas where there is high contrast between the white beach sands and the deep off shore waters.

The next major MOCEAN campaign is a cruise off the coast of NW Africa, during the season of major desert dust outbreaks over the Equatorial Atlantic. The main purpose is quantifying the accuracy that can be expected in the presence of significant quantities of dust, and providing additional data with which to fine-tune the atmospheric correction algorithm. In contrast to the Hawaii site, the waters in the area are very productive and will provide an excellent test area for validation of the bio-optical products as well. It also provides a good opportunity to study the effects of upper troposphere dust and aerosols on SST. After this W Africa cruise, the M-AERI will be deployed in Baffin Bay to study SST retrievals through polar atmospheres.

Approximately 1 year after launch, Carder will conduct a cruise in the Middle Atlantic Bight (MAB) for the purpose of studying the transition between Case 1 and Case 2 waters. This is accomplished by traversing lines from the Gulf Stream into the shelf water and finally the turbid near-shore waters.

Three large full MOCEAN campaigns will take place in the 2000-2001 time frame. The first will be in the Southern Ocean staged from Tasmania for the purpose of validating the algorithms and MODIS products at high latitudes, the second will be for validating the algorithms (atmospheric correction in particular) in a region in which anthropogenic aerosol resulting from urban pollution transported by the winds over the ocean (MAB), and the third will be off Hawaii for initialization of MODIS PM-1. Two shorter cruises will be carried out to validate the CDOM (Carder) and coccolith/calcite (Balch) algorithms.

4.3 Other Validation Methods

In addition to comparing surface data with MODIS retrievals on a pixel-by-pixel basis, we also plan to validate MODIS data by looking at long-term trends in the derived products. An example of this is the Evans and Gordon

(1994) study of the calibration variations of the CZCS over the life of the mission. Briefly, much can be learned by examining the stability of the retrievals over large spatial and temporal scales, e.g., are there non-explained “jumps” or fluctuations in the results? Are there unexplained long-term trends? A vigorous MOCEAN effort is planned in this regard.

4.4 Other Satellite Data

The MODIS bio-optical products will be compared with similar retrievals from SeaWiFS, OCTS, GLI, MERIS, POLDER, MISR, and any additional MODIS instruments in orbit, i.e., MODIS PM-1 will be compared with MODIS AM-1. The MODIS SST product will be compared with similar retrievals from AVHRR, AATSR, and GLI.

4.5 Measurement Needs at Calibration/Validation Sites

In order to validate the MODIS Ocean Products in the visible, it is necessary to obtain measurements of several environmental parameters in addition to the product being validated, e.g., in the case of atmospheric correction (water-leaving radiance) it is necessary to make a suite of measurements aimed at understanding the state to the atmosphere at the time of the retrievals. The Tier 1 MOCEAN at-sea validation effort consists of the MOCE campaigns. A listing of the quantities to be measured on these cruises is provided in the following table.

Measurement Suite for Typical MOCE Campaigns

Incident Spectral Irradiance	Downwelled Spectral Irradiance
Upwelled Spectral Irradiance	Upwelled Spectral Radiance
Upwelled Spectral Radiance Distribution	Sky Radiance & Polarization Distribution
Aerosol Vertical Distribution (MPL)	TIR Radiance (M-AERI) (Occasional)
Whitecap Spectral Reflectance Aug.	Spectral Solar Atmospheric Transmission
Water-Leaving Radiance	Attenuation Coff. of Upwelled Irradiance
Downwelling Irradiance Attenuatuion	Attenuation Cofficients Radiance
Spectral Reflectance	Beam Spectral Attenuation Profiles
Phytoplankton Pigments (HPLC)	Phytoplankton Pigments (Fluorimetric)
Cyanobacteria Pigments (Exp. Fluorimetric)	Fluorescence Profiles
Chl a Profiles	Trackline Salinity
Trackline Temperature	Trackline Beam Attenuation (530 nm)
Trackline Chlorophyll a	Total Suspended Material
Inorganic Suspended Material	Organic Suspended Material
Detritus Spectral Absorption Coefficient	Particle Spectral Absorption Coefficient
Particle Size Frequency Distribution	Particulate Organic Carbon
Particulate Organic Nitrogen	Primary Productivity (Occasional)
Phytoplankton Speciation Videos	Secchi Disk Depth
Atmospheric Pressure	Relative Humidity
Wind Velocity	Sea & Sky State Photographs

In addition we will utilize atmospheric data from the Tropical Western Pacific and the Arctic ARM sites in the validation of SST.

For large spatial scales Tiers 4 and 5 we will employ optical and SST drifters to provide validation. This will require procurement and launching of approximately 100 of each kind (optical and SST) per year throughout the life of the mission.

In the coarse of preparing this plan, there were several MOCEAN Team augmentations identified for which funding is undetermined. These are:

- Whenever feasible, physical observations should be added to biological sites. Additional measurements could include wind speed and direction, relative humidity, air temperature at the sea surface, waves, fluxes, and surface radiation.

- Additional (3-4) M-AERI or equivalent instruments should be procured.

- An additional 3-4 MOBY units should be constructed and deployed, e.g., one at high latitudes, one in the Saharan dust zone, and one in the Middle Atlantic Bight.

- Two high latitude (as opposed to one now planned) Tier 1 focus study sites are needed to establish aerosol effects and differences between the two hemispheres. SST, ice temperature, and radiation should be included in this suite of measurements.

Finally, the MOBY (Hawaii), MAB, and NASDI (N.W. African Saharan Dust Input) and other (as yet to be determined) SST, campaigns require P-3 and ER-2 aircraft support. Shipboard resources are still undetermined for the MOBY and MAB campaigns; however, NASDI will need at least one 250 ft class 1 vessel and one 150 ft class 2 vessel.

4.6 Needs for Instrument Development

Although we have at least one set of instrumentation available for each of the required parameters, several instrument developments would help facilitate the completion of this plan. These include:

- Deployable fiber-optics based radiometers to minimize the effects of in-water instrument self shading.

- Portable reference lamps for rapid checking of calibration for *in situ* radiometers.

- Anti-fouling compounds or strategies for keeping the windows of unattended *in situ* radiometers clean.

- Small, inexpensive, stable, broad-band IR thermometers for rapid measurement of sea surface “skin” temperature.

- Portable Pump and Probe and Fast Repetition Rate Fluorometric systems for measurement of primary productivity.

- Standards for particle absorption.

4.7 Geometric Reference Sites

No new reference sites are required, a sufficient number having been established for SeaWiFS.

4.8 Intercomparisons

Our primary effort is focused on comparison of the MODIS-retrieved products with *in situ* observations. This is effected through the match-up database (MDB) being developed at the University of Miami by R. Evans. A secondary effort is to compare MODIS retrievals with similar retrievals from other sensors: MISR, SeaWiFS, OCTS, GLI, etc. This will carried out in cooperation with the SIMBIOS Project.

5.0 Implementation of Validation Results

5.1 Approach

A key component of the validation exercise, in addition to the collection of data and comparison with MODIS retrievals, is the concomitant increase in understanding the operation of the MODIS system (sensor *plus* algorithms) required to fine-tune the geophysical algorithms in a rational manner. This fine tuning process is particularly important for the atmospheric correction process in the visible, which requires candidate aerosol models and a more accurate sensor calibration than can be provided by traditional approaches. (This calibration is established during the "initialization" process). The results of the initial validation campaigns will be used during the first year to effect this fine-tuning of the algorithms and the calibration coefficients. Following this, a period of intense evaluation of the MODIS products in which the consistency and stability of the data and the applicability of the retrievals to validation data acquired at Ocean Test Sites, will take place. We expect the algorithms to be stable within the first year after launch; however, some changes will be required during the second year as more specific areas are examined, e.g., the effects of anthropogenic absorbing aerosols transported over the oceans (MAB campaign). The first-year reprocessing of MODIS data will take place at Team Member Computing Facilities, with full-scale reprocessing of the first-year data at the DAAC to begin near the middle of the second year of data, i.e., after the results of the MAB campaign are available.

5.2 Role of EOSDIS

There are two critical roles for EOSDIS. First is providing the required Level 1 and Level 2 data to be validated to MOCEAN in a timely manner. This will require that EOSDIS establish a high-speed networking capability for transferring the data. Within the MODIS Ocean Group, we have developed the capability of combining the MODIS-derived products with the corresponding *in situ* measurements on a pixel-by-pixel basis, the MDB at University of Miami. This is will be the platform for processing the MODIS validation data. The second role of EOSDIS is to provide an archive of the validation data, which will be provided from the MDB.

5.3 Archival of Validation Data

All data collected as part of team member validation activities will be permanently archived within the larger EOSDIS framework. Initially, these data will reside within local data bases at individual Team Member Computing Facilities, and copies will be transferred to the central sites, the MDB at U. Miami and SeaBASS at GSFC (expected to be under the SIMBIOS Project). It is essential during the test and evaluation phase, that the quality assessment of the *in situ* data be the direct responsibility of the individual Science Team Members. When algorithms mature, the responsibility for maintaining these data bases, and incorporating new data, should shift to the appropriate DAAC.

6.0 Summary

We will revise this validation plan prior to the launch of MODIS AM-1 based on experience gained by examination of data from SeaWiFS and OCTS. However, it must be recognized that unforeseen problems, e.g., a significant deviation of the MODIS performance from expectations, will likely require *in situ* observations in addition to those described in the present plan or its revision.

7.0 References

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8.0 Acronyms

AASTR	Advanced Along Track Scanning Radiometer
ADEOS	Advanced Earth Observation Satellite
AERI	Atmospheric Emitted Radiation Interferometer
AERONET	Aerosol Robotic Network
ARM	Atmospheric Radiation Measurement Program
ASTER	Advanced Spaceborne Thermal Emission and Reflection radiometer
ATBD	Algorithm Theoretical Basis Document
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BATS	Bermuda Atlantic Time Series
CERES	Clouds and the Earth’s Radiant Energy System
CDOM	Chromophoric Dissolved Organic Matter
CZCS	Coastal Zone Color Scanner
DAAC	Distributed Active Archive
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ENSO	El Nino/ Southern Oscillation
GCOS	Global Climate Observing System
GLI	Global Imager
GOES	Geosynchronous Observing Environmental Satellite
GSFC	Goddard Space Flight Center
HPLC	High Performance Liquid Chromotagraphy

HOTS	Hawaii Ocean Time Series
IRS	Indian Research Satellite
JGOFS	Joint Global Ocean Flux Study
M-AERI	Marine-AERI
MAB	Middle Atlantic Bight
MDB	Match-up Data Base
MERIS	MEdium Resolution Imaging Spectrometer
MISR	Multi-angle Imaging Spectro-Radiometer
MOBY	Marine Optical Buoy
MOCE	Marine Optical Characterization Experiment
MODIS	Moderate Resolution Imaging Spectroradiometer
MOS	
MSX	Midcourse Space eXperiment
MPL	Micro Pulse Lidar
NASDA	NAtional Space Development Agency of Japan
NRA	NASA Research Announcement
OCTS	Ocean Color and Temperature Sensor
POLDER	Polarization and Directionality of Earth's Reflectances
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SeaBASS	SeaWiFS Bio-optical Archive and Storage System
SIMBIOS	Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies
SST	Sea Surface Temperature
TARFOX	Tropospheric Aerosol Radiative Forcing Observational Experiment
TOMS	Total Ozone Mapping Spectrometer
WMO	World Meteorological Organization